Research Application Summary

Improvement of sorghum for tolerance to stress and increased production and utilisation in Kenya

Gudu, S., Onkware Osoro, A., Were Angiyo, B., Too Jepkosgei, E., Ochuodho Onyango, J., Okalebo, J.R., Othieno Obiero, C. & Kisinyo Oloo, P.
Chepkoilel University College, Moi University, P. O. Box 1125-30100, Eldoret Kenya
Corresponding author: juliusochuodho@yahoo.com

Abstract

Sorghum is an important food security crop in sub-Saharan Africa, including eastern Africa but grain yields are very low. This is due to the many stresses it goes through during production in addition to use of unimproved genotypes. The objective of this project was to select, develop and promote sorghum lines that can withstand both abiotic and biotic stresses prevalent in eastern Africa. Sorghum genotypes were collected, lines developed and tested against various stresses, and data collected and analysed. Many genotypes adapted to the various stresses have been developed. Some lines have been submitted for variety release process including Nyadundo 1 and Nyadundo 2, MCSRV E94, MCSR N4, which are drought tolerant, *Striga* tolerant and can withstand some of the diseases.

Key words: Kenya, *Sorghum bicolor*, varietal development

Résumé

Le sorgho est une importante culture pour la sécurité alimentaire en Afrique sub-saharienne, y compris l'Afrique orientale, mais les rendements en grain sont très faibles. Ceci est dû aux nombreux stress qu'il traverse au cours de la production, et en plus à l'utilisation des génotypes non améliorés. L'objectif de ce projet était de sélectionner, développer et promouvoir les lignées du sorgho qui peuvent résister à la fois à des contraintes abiotiques et biotiques fréquentes en Afrique orientale. Les génotypes du sorgho ont été collectés, les lignes développées et testées contre les divers stress, et les données collectées et analysées. Beaucoup de génotypes adaptés aux différentes contraintes ont été développés. Certaines lignes ont été soumises pour le processus de lancement des variétés, y compris Nyadundo 1 et Nyadundo 2, MCSRV E94, MCSR N4, qui sont tolérantes à la sécheresse, tolérantes au *Striga* et peuvent résister à certaines maladies.

Mots clés: Kenya, *Sorghum bicolor*, développement variétal

Background

Sorghum (*Sorghum bicolor* (L.) Moench) is a major food security crop for over 100 million people in sub-Saharan Africa. It can also be used in breweries, animal feed formulation or even feedstock in bioethanol production (Ebiyau *et al*., 2005). Sorghum is endemic to Africa, and is relatively more tolerant to water and high temperature stresses than most of the other popular cereals. Production of sorghum in Eastern Africa is characterised by low grain yields because of many factors, key among which include use of unimproved cultivars, excessive water stress, low soil fertility (especially low available phosphorus), widespread soil acidity (and associated aluminium toxicity), weed (especially *striga*) infestation and diseases (especially anthracnose and turcicum leaf blight, among others), and pests (especially the midge, shoot fly and birds).

It has been argued that improving production of the staple crops is the easiest way to improve the lives of a majority of the population in sub-Saharan Africa because more than 65% of the people in this region depend directly on agriculture for livelihoods (Nelson *et al.,* 2010; Asenso-Okyere and Jemaneh, 2012). Indeed sorghum is ranked 7th as a source of calories in the low income, developing countries, and improving its production, therefore, can have significant positive effect on food security.

The sorghum research team at Moi University, in collaboration with other researchers and stakeholders has been involved in sorghum improvement for close to ten years. The purpose of the research was to select, breed and promote sorghum lines that are tolerant to drought, soil acidity, midge and anthracnose; characterise sorghum seed systems and promote alternative uses of sorghum in Eastern Africa: Ethiopia, Kenya, Tanzania and Uganda.

Study Description

The team, with the funding support from BIOEARN, collected over 400 sorghum land races, ICRISAT lines and commercial varieties which were tested and selected for yield in two sites, Bumala (0°18' N, 34°12', 1414 m) in Western, and Sega (0°15' S; 34°12' E, 13°84 m) and Karungu (0°49' S, 34°07' E, 1260 m) in Nyanza region of western Kenya. Sorghum production and consumption is relatively higher in the two regions compared to other parts of Kenya.

The preliminary selection set up comprised single rows per sorghum accession with three replications and yield was

assessed as quantity of grain per plant. The other properties that were assessed included plant height, tillering, field duration and grain colour. Breeding, and seed multiplication and maintenance were carried out in the field at the Kibos KARI-CYMMIT site (0°°02' N, 3449' E, 1304 m). Selected accessions were subjected to aluminium (acidity) stress (Cheprot, 2010; Ringo, 2010; Ringo *et al.*, 2010; Too, 2011) water stress (Okiyo 2010, Okiyo et al,. 2011, Langat 2012), striga, and low soil phosphorus (Maritim, 2011) stress, anthracnose (Were, 2011) and sorghum midge (Okora, 2011). Seredo, a popular commercial variety in Kenya, was used as a standard. Participatory farmer selection was carried out in Western region and at Kibos. This was done in collaboration with Embrapa (Brazil), ICRISAT, Makerere University, Mekelle University, Cornell University and Purdue University through funding by AGRA, McKnight, GCP, Kenya National Council of Science & Technology, among others.

The anthracnose and *Striga* infestation research has been more involving, because of the behaviour of these biotic stresses in the field. Some putative accessions or breeding lines have been identified that are tolerant to these stresses, and further research is going on concerning their attributes. Phosphorus efficiency studies are also ongoing.

Research Application

The accessions vary significantly in several attributes, including yield, height, days to 50% flowering and mature grain colour (Table 1). Breeding lines, Nyadundo 1 and Nyadundo 2, MCSRV E94, MCSR N4, yielded more than the commercial varieties Serena, and Wagita.

There were apparent differences in the performance of different sorghums in the *Striga* infested field in Karungu (Fig.1). It was noted that some of the putatively tolerant lines did not have a large population of *Striga* growing under their canopies, whereas others performed well in spite of a large under canopy *Striga* population. The apparently tolerant lines or accessions will be further tested under controlled conditions

There were significant differences in the performance of the sorghums under water stress. Some of the lines, such as MCSRV, Nyadundo 1, MCSRV G2, flowered and matured early, whereas others such as MCSRV N4, flowered and matured late. However, the grain of MCSRV G2 was devastated by birds.

Table 1. Properties of selected sorghum accessions grown in Karungu, 2011.

Accession	Yield (kg/ha)	Height (cm)	50% flowering (days)	Colour
MCSRV Nyadundo 1	2233	151	67	Red
MCSRV N4	1953	166.	77	Red
MCSRV E94	1833	181	70	L.Brown
MCSRV F14a	1373	136	69	Brown
MCSRV E36-1	1100	146	69	White
MCSRV wagita	860	157	70	Red
Serena	833	146	66	L.Brown
MCSRV G2	260	166	69	White
D1	250	128	68	Brown
MCSRV Nyadundo 2	2020	136	67	Red
Serena	1705	137	69	L.Brown
MCSRV E49	1700	127	76	L.Brown
MCSRV C26	1650	140	76	L.Brown
MCSRV A3	1580	141	74	White
MCSRV C1	1500	117	65	White
MCSRV MR732	1580	119	76	White
MCSRV T30	1550	84	74	L.Brown
MCSRV E40	817	135	72	Cream

MCSRV Nyadundo 1 MCSRV G2

Figure 1. Performance of selected sorghum breeding lines on a *Striga* infested field in Karungu (2011); The MCSRV N4 also stays green for longer even after grain maturity under drought conditions.

The effect of anthracnose, turcicum leaf blight and other diseases was varied (Fig. 2). More tests are however being carried out to ascertain the true reactions of these lines to diseases.

References

Asenso-Okyere, Kwadwo and Jemaneh, Samson. 2012. Productivity and enhancing food security in Africa. New challenges and opportunities. Synopsis of an International Conference. International Food Policy Research Institute.

Cheprot, Kiboi Reuben. 2010. Characterization of Kenyan sorghum lines for aluminium tolerance and genetic diversity. M. Phil. Thesis, Moi University.

Figure 2. An anthracnose infected sorghum line at Kibos.

Ebiyau, J., Arach, T. and Serunjogi, L.K. 2005. Commercialisation of sorghum in Uganda. *African Crop Science Conference Proceedings* 7: 695-696

Langat, Zeddy, 2012. Tolerance of selected sorghum lines to water stress at different stages of development. M. Phil. Thesis, Moi University.

Maritim, Kassim Kipkemboi. 2010. Phosphorus efficiency among cultivated sorghum and segregating families. M. Phil. Thesis, Moi University.

Nelson, Gerald C., Rosegrant, Mark W., Palazzo, Amanda; Gray, Ian, Ingersoll, Christina, Robertson, Richard, Tokgoz, Simla, Zhu, Tingju, Sulser, Timothy, B., Ringler, Claudia, Msangi, Siwa and You, Liangzhi. 2010. Food security, farming, and climate change to 2050: Scenarios, Results, Policy Options. International Food Policy Research Institute (IFPRI).

Okiyo, T., Gudu, S., Kiplagat, O. and Owuoche, J. 2010. Combining drought and aluminium toxicity tolerance to improve sorghum productivity. *African Crop Science Journal* 18(4):147 - 154.

Ringo, J.H. 2010. Breeding and selection of sorghum (*sorghum bicolor* L. moench) for adaptation to acid soils of Tanzania. M. Phil. Thesis; Moi University.

Too, Emily J. 2011. Physiological and molecular characterization for aluminium resistance in selected grain sorghums. D. Phil. Thesis, Moi University.

Were O Javan. 2011. Reaction of advanced sorghum genotypes to *Colletotrichum spp*. in the Lake Basin region of Kenya. MSc Thesis, Moi University.